ttbl_indexes_snap

ttbl_indexes is a small Python program that is able to calculate 6th order accurate thickness parameters $(\delta_{99}, \delta^*, \theta)$ from the averages of snapshots of temporal turbulent boundary layer (TTBL) simulations. It also calculates the related Reynolds numbers $(Re_\tau, Re_{\delta^*}, Re_\theta)$, the streamwise shear velocity $u_{\tau x}$, streamwise friction coefficient c_{fx} and Reynolds analogy factor A_{fact}. Results are saved in `/data_post/ttbl_indexes/thickness_params.txt`.

The program also calculates non-dimensional grid spacings and domain dimensions, and stores them in the file `/data_post/ttbl_indexes/nd_mesh_evolution.txt`. Moreover, the minimum Kolmogorov time scale τ_η and the viscous time unit t_ν are calculated and stored in the file `/data_post/ttbl_indexes/time_scales_evolution.txt`. For both space and time resolutions, we adopt the total shear velocity in order to be on the safe side.

Requirements

`ttbl_indexes` employs mean statistics calculated with `post_incompact3d`. The script is able to automatically open each `mean_stats`, `vort_stats` and `diss_stas` files, based on inputs given through `post.prm`. Time-units are read from the `.xdmf` snapshots' headers in a flow realization folder asked to the user.

High order interpolation

The mean velocity profile is reconstructed with the SciPy function `InterpolatedUnivariateSpline`, with a spline of order 5 that passes through all data points. Integrals are evaluated with the `integral` command of the same function. In this manner, the integrals calculated are 6th order accurate.

List of calculated quantities

- BL thickness δ_{99} (O(6))

$$\delta_{99} \equiv y : \langle u(y) \rangle = 0.01 U_w$$

- Displacement thickness (O(6))

$$\delta^* = \int_0^\infty \frac{\langle u \rangle}{U_w} dy$$

- Momentum thickness (O(6))

$$\theta = \int_0^\infty \frac{\langle u \rangle}{U_w} \left(1 - \frac{\langle u \rangle}{U_w}\right) dy$$

- Friction Reynolds number (O(6))

$$Re_\tau = \frac{u_{\tau x} \delta_{99}}{\nu} = \delta_{99}^+$$

- Reynolds number based on displacement thickness (O(6))

$$Re_{\delta^*} = \frac{U_w \delta^*}{\nu}$$

- Reynolds number based on momentum thickness (O(6))

$$Re_\theta = \frac{U_w \theta}{\nu}$$

- Streamwise shear velocity (O(6))

$$u_{\tau x} = \sqrt{\nu \left| \frac{\partial U}{\partial y} \right|}$$

- Streamwise friction coefficient (O(6))

$$c_{fx} = 2\left(\frac{u_{\tau x}}{U_w} \right)^2$$

- Reynolds analogy factor

$$A_{fact} = \left| \frac{\frac{\partial \Phi}{\partial y}}{\frac{\partial U_\parallel}{\partial y}} \right|_w$$

- Kolmogorov time scale

$$\tau_\eta = \sqrt{\frac{\nu}{\varepsilon}}$$

- Viscous time unit

$$t_\nu = \frac{\nu}{u_\tau^2}$$